# DISCOVERY OF JUVENILE LUNG-FISHES, WITH NOTES ON *EPICERATODUS*.

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Plate XIX.

*Introduction.*—It is gratifying to be able to report the discovery of juvenile Ceratodus in the Enoggera Reservoir, near Brisbane. With the exception of specimens which had been bred from ova in artificial conditions, in which the maximum period of survival was two years (Bancroft, 1918, p. 92),* no juvenile Queensland Lung-fishes had previously been seen.

During the process of clearing the reservoir of the prolific "water hyacinth" (*Eichhornia speciosa*), matted masses of this weed were pulled on to the bank near "the bywash" on 29th February, 1928, and on 2nd March, and seven young Ceratodus were found hiding in this material. These were transferred to cans and brought to the Queensland Museum, where they were placed in one of our large aquaria. The actual maximum lengths in millimetres of the specimens were as follows:—

Reg. No. I. 4436, 150; I. 4437, 146; I. 4438, 110; I. 4441, 148; I. 4442, 150; I. 4443, 145; I. 4444, 96.

It will be seen that, at the time of transference to the aquarium, the juvenile Ceratodus ranged from 96 to 150 mm. in maximum length.

It is my pleasant duty to express keen appreciation of the work done by officers of the Metropolitan Water Board in carefully preserving this material. The President, Mr. E. J. T. Manchester, and also Mr. C. G. Ede, have taken a special interest in this matter.

In view of the great interest attached to these remarkable fishes, it has been considered advisable to give a short account of these specimens and also of the adults in our aquaria, together with a concise historical résumé of the work done on Ceratodus, with some references to the voluminous literature of the subject.

*Transportation.*—In his "Report on Preservation of Ceratodus," given to the Royal Society of Queensland in September, 1896, D. O'Connor gave interesting information regarding the transference of sixty-nine live specimens

* References are given at the end of paper.

to new habitats in 1895 and 1896. In the first place 109 specimens were caught in the Mary River, near Miva, and its tributary Munna Creek. Of the sixty-nine suitable for transport, eight were put in the North Pine River, five in a lagoon near the Albert River, eight in a dam at Cressbrook communicating with the Brisbane River, eighteen in the Enoggera Reservoir, twenty-one in the Condamine at Warwick, sixteen in the Upper Coomera, two in the Botanic Gardens pond, and one was used for public exhibition. All of the specimens were large fish, ranging from "thirty-three to forty-five inches in length and were from nine to fourteen lb. in weight." These Ceratodus were successfully transported in boxes containing river weed which was kept moist. O'Connor notes (1910, p. 384) that the fish were so flexible that one of them was able to reverse its position in its narrow compartment.

*Transportation Overseas.*—In 1898 O'Connor successfully transported four large Ceratodus from the Mary River to London and Paris. Two of these were placed in the Zoological Gardens, London, in June of that year, and one of these died in 1915. The other lived until 31st December, 1927, nearly twenty years later ("Field," London, 21st January, 1918). These two fishes were the subject of Bashford Dean's interesting articles (1906 and 1912), which added much to our knowledge of Ceratodus.

*Absence of Juvenile Specimens.*—In 1893 Thomas Illidge, in a paper on Ceratodus, stated that he had been on the Burnett for six years and had never seen nor heard of a Lung-fish less than 4 lb. in weight. Mr. Thomas Welsby (1905, p. 180) quotes from information given by Mr. Illidge to "The Courier" that the smallest specimen caught was fifteen inches long. In 1911 T. L. Bancroft pointed out that "no one seemed ever to have caught a small Ceratodus," and that even the Aborigines "were unable to find the little fellows" (p. 251). Bancroft considered that the Lung-fishes were nearing extinction, and that in an ordinary season no newly hatched fishes succeed in escaping from their numerous enemies. Later (1924) he suggested that a biological laboratory should be established in the Blue Lake on Stradbroke Island where young Ceratodus could be reared in a protected hatchery. He also suggested that by mating Burnett River with Mary River specimens a more robust progeny might be secured (1924, p. 19).

The smallest specimen handled by D. O'Connor was twenty-six inches, but he notes (1910, p. 384) that a Ceratodus about fourteen inches in length was taken from mud in a dry season on the Burnett River, according to Mr. H. H. Wilson, of Coranga Station.

The smallest specimen in the Queensland Museum is I. 2528, 321 mm. in maximum length, obtained from the Burnett River in November, 1915, presented by Mr. H. Wilson. Another specimen, 367 mm., found during a heavy flood in Quay street, Bundaberg, in 1912, was presented by the late Dr. T. H. May. This was recorded by J. Douglas Ogilby in 1912. A specimen 400 mm.

in length was exhibited by Dr. T. Harvey Johnston before the Royal Society of Queensland (1915, p. 58). This was sent from Eidsvold by Dr. T. L. Bancroft.

In September, 1918, the writer exhibited before our Royal Society a specimen 495 mm. long, which was caught in the Coomera by Messrs. Whalley Bros., and presented to the Queensland Museum through Mr. A. A. Gilmour, manager of the State Fisheries. This relatively small specimen must have been bred in the Coomera from the large ones introduced by O'Connor in August, 1895.

According to D. O'Connor (quoted by T. Welsby, p. 184) there was evidence that a new generation of Ceratodus had been bred in the Condamine, but no specimen was forthcoming.

In December, 1913, we received a large specimen (I. 1629) from the Caboolture River.

*Notes on Juvenile Specimens.*—As was to be expected from the descriptions and illustrations of tiny Ceratodus bred from ova, these juvenile Lung-fishes closely resemble adults in contours and proportions. The vertical height of the posterior part of the body is considerably greater than that of the head or middle portion. These young specimens are variegated above in comparison with the uniform colour of adults. The ground colour is "ochraceous buff" (Ridgway), but this is mostly submerged in the clove-brown mottling closely distributed over the body. On the tip of the snout and on the tail the ochraceous buff colour is more prominent owing to the sparseness of the mottling. These darker spots are irregular in size and distribution. The paired fins are also mottled, but this is only noticeable in very clear water.

No accurate measurements could be made on the living specimens, but it is obvious that the posterior limbs are relatively smaller than in adults. As was shown by Semon, the anterior pair are well developed before the others appear. On the upper surface of the head there are numerous tiny perforations. These were noted by Gunther (1871, p. 514), and also may be seen in Semon's beautiful illustrations (1893, Plate VIII). The eyes are small and inconspicuous. In colour they are blue-grey, with a thin yellowish ring around the dark centre. The lower surface of the body is purplish grey.

These juvenile Lung-fishes lie on the bottom in the darker parts of the aquarium. They may be barely distinguishable, as they are often partly buried in sand and covered with débris. They prefer to lie in small hollows or half-hidden among the roots and stems of *Vallisneria*. It requires a keen eye to detect them in these conditions, and they are barely recognisable as fishes.

*Aquatic Breathing.*—When quiescent they breathe through their gills about fifteen times a minute, but when disturbed this may be increased to at least sixty-eight times. Apparently they breathe more through the mouth than with the nostrils, for the lower jaw is perceptibly opened with each inhalation.

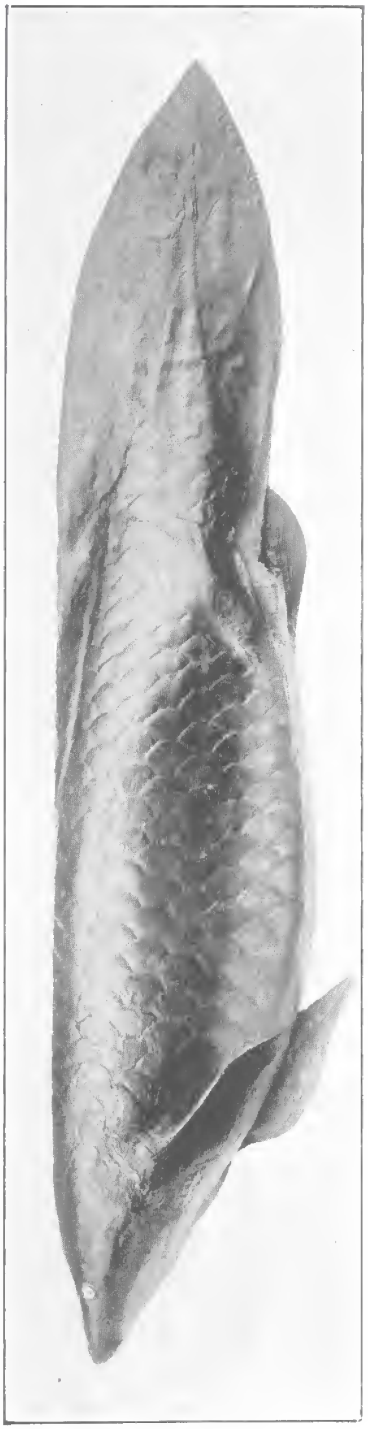

Fig 1.—*Epiceratodus forsteri* (Krefft). From cast in Queensland Museum.

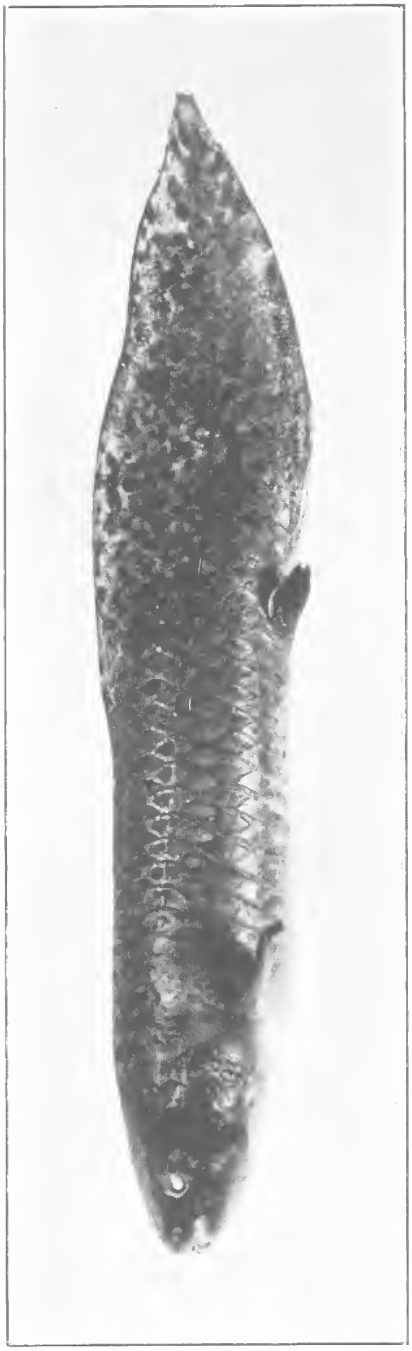

Fig. 2.—*Epiceratodus forsteri*. Juvenile specimen. Actual size.

*Use of Lung.*—The lung is very rarely used in normal conditions in the clear water of the aquarium in daytime. When disturbed, however, they have been seen to rise to the surface and take in air, the subsequent escape of which has been shown by bubbles, but this is most exceptional. Bancroft (1913, p. 2) noted that his tiny specimens, bred from ova, "never come to the top to breathe air."

*Food.*—When a live worm is placed in the aquarium the young Ceratodus will sometimes become aware of it in a few minutes and will move from their hiding-places near by. They will gradually approach the worm, moving forward slowly by short jerks, mainly as the result of quick propelling strokes with the pectorals. Should another Lung-fish appear after the worm is actually seized, the first one will sometimes scurry away with it. Apparently they cannot easily bite their food, and they will endeavour to swallow a whole worm, which may be several times disgorged before finally devoured. In this stage the tiny dental plates have little cutting power, and even in the preserved specimen 367 mm. in length the "teeth" are barely raised above the surrounding tissues. Doubtless these plates have considerable crushing powers. Illidge reports that adult Ceratodus use the vomerine teeth for gnawing the bark of trees growing in the water (1894, p. 41). In addition to worms the young Ceratodus feed on shredded pieces of raw beef, a small quantity of which is given to them once a week.

On dull days towards evening and at night they are far more active. At night they may be seen right at the top of the tank, and they appeared to be feeding on algal growths on the water-weeds. Occasionally a young Ceratodus will tilt itself almost upon its head in order to swallow some bit of vegetable débris.

These small Lung-fish are quite defenceless when chased by other fishes, apart from their speed. At first it was necessary to place them temporarily in an aquarium with four "climbing perch" (*Anabas*), but after two days it was found that the perch were chasing the Ceratodus and nibbling at their fins. Immediately the tank was emptied and the perch were put elsewhere. Considerable difficulty was found in locating all the Ceratodus.

These juvenile specimens combine extreme sluggishness and torpidity with a capacity for quick movement when necessary. When disturbed they will dart from end to end of the aquarium with remarkable rapidity, the large caudal fin being used with great effect.

Their eyesight appears to be very poor, and they will sometimes swim swiftly against the wall or a stone. They made no movement when a bright light was flashed on the glass within an inch of them. Unlike most fishes they appear to be insusceptible to vibrations.

*Aquarium.*—The juvenile Ceratodus are living in a capacious aquarium which is over 8 feet in length and about 2 feet wide. This contains about 20 inches of water above several inches of sand. Numerous plants of *Vallisneria* and *Hydrilla* are present. Four adults are in an adjoining aquarium of similar proportions.

*Development from Ova.*—The ova of Ceratodus were discovered by W. H. Caldwell in September, 1884. After much difficulty, "as the enemies of the Ceratodus were very numerous," he succeeded in rearing Lung-fishes from ova, and one was taken alive to Sydney and exhibited at the December meeting of the Royal Society of New South Wales (Caldwell, 1885, p. 120). He noted the enormous amount of gelatinous matter surrounding the egg and the resemblance between the development of the Ceratodus and that of amphibians.

In 1893 Thomas Illidge noted the immobility of the newly hatched fish and their helplessness (p. 43). He gives quite a detailed account of the early changes in the ova after deposition. He reared and preserved specimens showing various stages of growth from one to sixty-seven days, and a series of these was preserved and placed in the Maryborough School of Arts. Later he reared twelve specimens to six or eight months, but having to take these from Gayndah to Gladstone they perished through want of suitable water. Mr. Thomas Welsby (1905, p. 180) reprints some of Illidge's information as given to the "Brisbane Courier" in July, 1902. Mr. Welsby subsequently visited Maryborough, and a concise description of the young Lung-fish preserved there appears in his book (p. 187-190).

Richard Semon arrived in Queensland from Jena in 1891, and as a result of collecting through two seasons on the Burnett he secured a valuable range of material. After many difficulties Semon ultimately obtained a fine series of young Ceratodus representing all stages up to ten weeks. Some of this material was secured by letting the ova develop in "breeding-chests," protected by fine net of wire gauze, which were anchored in the river. His fine monograph on the development of Ceratodus, with its profuse and beautiful illustrations, was published in Jena in 1893. In his popular work (1899) Semon points out that the eggs of Ceratodus are extremely frail and tender, and that there was no possibility of a natural transportation by water-birds or aquatic animals to another river. Without special attention the eggs placed in vessels died off rapidly. Semon recorded (p. 201) that some of his tiny fish, bred from ova, died as the result of "an ample dinner of meat" given by a misguided enthusiast.

Thomas L. Bancroft in 1913 (pp. 1-3) recorded a method of hatching Ceratodus ova by isolating individual eggs in bottles. Later (1918, pp. 91-94) he succeeded in rearing specimens for longer periods, one of which survived to two years of age, and "it had hardly reached the length of 5 inches." In 1915 some of Dr. Bancroft's material was exhibited before the Royal Society of Queensland by Dr. T. Harvey Johnston.

It is clearly demonstrated that there is no larval metamorphosis in our Lung-fishes. No cutaneous gills or cement organs are present in the early stages, as in the African *Protopterus* or the South American *Lepidosiren*, in which the lung is double (Dipneumones).

*Adult Specimens.*—Four living Ceratodus are at present in an aquarium here. One of these was received from Dr. Bancroft, Eidsvold, Burnett River, in May 1924, and was then approximately 2 feet in length. Three others were received from Dr. Bancroft in May 1926, and these ranged from 2 feet 7½ inches and 2 feet 8½ inches, to 3 feet 4½ inches. These specimens have never deposited ova, and they have never exhibited the "deep orange-red" colour on the ventral surface noted by Schmeltz (1876, p. 138), which may be associated with the breeding season. The general colour of the body, apart from the ventral surface, is clove-brown with a greenish tinge, and this colour extends to the paired fins and the whole of the tail. The ventral surface of the body varies from whitish to pale yellow. At one time Dr. Bancroft considered that the males were yellow and the females pinkish, but he now doubts whether there are distinctive colours for the sexes. Our specimens all have a narrow white margin to the paired fins, and this feature was also noted by Bashford Dean. There is also a narrow whitish margin on the scales surrounding the eye.

The largest preserved specimen in the Queensland Museum is 41 inches. It is frequently stated that these Lung-fish grow to at least 6 feet, and there is a newspaper report of one obtained many years ago by Mr. H. Geisler, of Gayndah, which was 6 feet 7 inches, and weighed 82 lb. Baldwin Spencer (1892, p. 24) quotes 87 lb. as a record.

It is very evident that these adult specimens grow very slowly, and it has been suggested that a specimen which attained 6 feet would be about 100 years old.

*Breathing.*—There are serious discrepancies in the accounts of lung-breathing, so much so that it seems probable that some fish may use their lung much more frequently than others. Bashford Dean (1912, p. 611) notes a maximum of "over seventy minutes without either fish coming to the surface," in the London Zoological Gardens. Although he states that these fish came from the Burnett River (1906, p. 169) it is definitely known that they came from the Mary River. In 1906 he reported that lung-breathing took place at irregular intervals, from forty to sixty minutes. Semon saw his Burnett River specimens "appear at the surface every thirty or forty minutes" (1899, p. 92), and this is endorsed by Baldwin Spencer (1927, p. 250). Bancroft, however, points out that lung-breathing is very rare, and that one may watch for a whole afternoon without seeing it. There may be some variation between the Burnett and the Mary River specimens in this respect.

The adult Ceratodus from the Burnett in the large aquarium in the Queensland Museum, which were presented by Dr. T. L. Bancroft, have been rigidly watched on several occasions by relays of observers, and it may be definitely stated that all four specimens may remain beneath the surface from 9 a.m. to 5 p.m. The plate-glass front gives the maximum opportunity for observation, and it is obvious from years of experience here that in the hours of daytime the Ceratodus very rarely rise to the surface. As exhibits of lung-fishes they are in this respect most disappointing, especially in view of statements

in several text-books. It must be recorded, however, that they are living in perfectly clear water, with a sandy bottom. At feeding times or when mechanically disturbed they will frequently rise to the surface to breathe. At night, when they are much more active, they use the lung occasionally, but no maximum period can be given. In the daytime, except when feeding, they normally lie motionless on the bottom, and the greater part of their lives is passed in this condition. These observations confirm the remarks of several writers who consider that the lung is an auxiliary organ, which is chiefly used when the water is muddy or foul. Semon (1899, p. 93) quotes the experience of Mr. W. B. Maltby, of Gayndah, who found Ceratodus in excellent condition in a shallow waterhole in which mullet, perch, or other fish had died.

The slight noise, "spouting," made by the Ceratodus when emitting air at the surface has frequently been noted. This usually resembles a blast from a small bellows, and is chiefly noticeable in the silence of night. Possibly giant specimens may be responsible for the louder noise noted by Illidge and Semon.

*Aquatic Breathing.*—Ceratodus can obviously breathe through the nostrils when the mouth is closed, but they usually breathe directly through the mouth, and the movement of the lower jaw may be clearly seen. In 1876 Huxley pointed out that in Ceratodus, as in Lepidosiren, "the anterior nasal apertures were truly outside of the mouth, whereas Gunther had previously stated that these were "within the cavity of the mouth." On this minor anatomical point Huxley was right, as usual, for the external nasal opening may be seen from below when the mouth is closed. The aquatic breathing of adults is very variable, as noted by Bashford Dean (1912). This doubtless depends partly on temperature, but also on the activity or otherwise of the specimens. In the same aquarium at the same time our counts varied—26, 31, and 35 per minute for three specimens. When clearing the gills of extraneous matter, after feeding on corn, for instance, they frequently make two or three breathing movements in quick succession. When watched closely it is seen that the mouth is slightly opened with each inhalation. When the fish are mechanically disturbed aquatic breathing is much accelerated. Bashford Dean's excellent account of the rhythmic movements in breathing leaves little for other observers to add. When quiescent in water at a temperature of 65 deg. F. he noted breathing "about twelve times a minute."

In May 1926, three specimens were sent from Eidsvold to the Queensland Museum in wooden boxes filled with water-weeds. These were out of the water at least twenty-one hours, although water was poured over the weeds several times en route. When placed in the aquarium it was noted that the aquatic breathing was very rapid at first, being fifty times to the minute.

*Food.*—Baldwin Spencer (1892, p. 84) stated that the alimentary canals of Ceratodus examined by him in September were "filled with the fruit of the gum-tree *Eucalyptus terticornis* which overhangs the river bank." This material was uncrushed. W. Macleay had previously reported that the flowers

of *Eucalyptus* were eaten (1884, p. 211). Thomas Illidge (1894) notes that Ceratodus will take snails, worms, and moss, and that a shrimp forms the best bait for catching them on a line. Semon (1899) caught his Ceratodus with baits of meat or molluscs. He suggests that they eat water plants because of the shellfish and other little animals harboured by vegetable growth. O'Connor fed his specimens "mainly on prawns."

The adult specimens in the Queensland Museum feed readily on small pieces of raw beef. They will also devour water-weeds, lettuce, and apples, being evidently fond of the latter. Apples cut into small pieces were found useful, as the water was not easily fouled by decaying remnants. Following a suggestion from Dr. T. L. Bancroft, corn (maize) was put into the aquarium and this was relished. To our surprise, small fragments of crushed corn were occasionally expelled through the gill openings. Sweet potatoes, cut into small pieces, are also eaten, and food which was not taken in the daytime was usually finished at night.

Apparently the Ceratodus obtain their food more by smell than by sight, and in this connection it is interesting to note the unusual development of the olfactory lobes of the brain, recorded by Huxley (1876) and by several subsequent writers.

E. Ray Lankester quotes an interesting account by Dr. Bohls of the natural history of *Lepidosiren* (1894, pp. 11-12). The South American Lungfish cannot be taken on a line, and it feeds chiefly on a large marsh-snail, although vegetable matter is also taken.

*Habits.*—The first description of the habits of Ceratodus in captivity was given by E. P. Ramsay (1876), when living specimens were received at the Australian Museum from Maryborough. Ramsay's concise statement showed that Ceratodus was a sluggish fish which could not progress out of the water, which mainly used its tail when swimming, and which fed on worms, snails, and water-weeds.

C. Lumholtz (1889, p. 385) made the grotesque statement that at night Ceratodus "goes ashore, where it eats grass and leaves, while in the daytime it may be seen sunning itself on logs lying out of the water."

Baldwin Spencer (1892, p. 82) wrote, "The Ceratodus always stays in the deep pools." He pointed out that, unlike its ally *Protopterus*, it made no cocoon of mud during a season of drought, and the lung was useful as a "subsidiary organ of respiration." Unless surrounded with damp moss or weeds it only lived for eight or ten hours when taken out of the water.

Semon noted that the fish "avoids the river heads" and is "easily affected by sea water" (1899, p. 90). He describes it as "an uncommonly dull, slow, and lazy fish," and he compares its behaviour with that of a newt.

Illidge (1894, p. 41) writes, "After capture it is really the quietest fish I have ever seen." He notes the "fine oily substance" covering the scales, and the greenish-brown appearance of the back and a slaty colour on the belly in life.

In his two articles (1906 and 1912) on the Ceratodus in the Zoological Gardens in London, Bashford Dean gives a full and interesting account, with excellent sketches of its contours in various positions. He states that "its general behaviour suggests that of an amphibian, e.g. *Necturus*," and his subsequent remarks regarding its movements and feeding habits confirm this likeness to amphibians. He notes that the eyesight is poor and that the fish is "largely nocturnal in habits."

The best concise account of Ceratodus is that given by Sir Baldwin Spencer in "The Encyclopædia of Australia" (1927, pp. 248-250), but the statement regarding the use of the lung, following Semon, requires qualification, as shown elsewhere.

An excellent coloured plate of Ceratodus is given in "Fishes of Australia," by T. C. Roughley (1916, p. 192).

In 1916 T. Harvey Johnston listed three endoparasites from Burnett River specimens.

*Ceratodus Totally Protected.*—D. O'Connor stated (1898, p. 493) that in the early days the Ceratodus was used as food by settlers and miners, being mostly killed by dynamite. It is of interest to point out that the Ceratodus is now totally protected under "*The Fish and Oyster Act of* 1914."

*Nomenclature.*—In 1870 Krefft described the Queensland Lung-fish as a Ceratodus, having shrewdly recognised that the dental plates of this "gigantic amphibian," as he called it, were similar to the fossil forms described by Agassiz under that name. The specific name *forsteri* was given "in honour of its discoverer, the Hon. William Forster." A. Smith Woodward in 1890, when describing *Gosfordia* from the Hawkesbury series, pointed out that the Queensland fish would probably need a new name owing to its generic distinction from fossil species.

It is now generally recognised that the present-day Queensland Lung-fish and also the dental plates found in relatively recent deposits are generically distinct from those included in the genus *Ceratodus,* founded by Agassiz in 1838 for Triassic and Jurassic species. Owing to the introduction of the name "Neoceratodus" by Castlenau in 1876 for a fish, said to have come from the Fitzroy River, which he named "Neoceratodus blanchardi," some confusion has existed as to the generic name of our species. The status of Castlenau's fish is in doubt, and some of his work was so unreliable that little confidence can be placed in it. It may be mentioned that he established "Ompax spatuloides"—which Jordan suggests (1819, p. 399) may be based on *Epiceratodus*—on the sketch of a fish which had previously been eaten. Macleay (1882, p. 348) doubted the finding of this fish. In Comptes Rendus, vol. 82, 1876, p. 1034, a communication from Castlenau was read in which he distinctly expresses the opinion that his Fitzroy fish "Neoceratodus" was generically distinct from the Burnett River Ceratodus. Unfortunately the original description of the genus (Journ. Zoologie, v, p. 132) is not available here, but according to the Zool. Record (1876, Pisces, p. 7) a second reference denotes that Castlenau considered his

fish to be a juvenile Ceratodus (*loc. cit.*, p. 343). Although listed as "Neoceratodus" by many ichthyologists, we have followed Baldwin Spencer and later writers on fossil remains in using Teller's genus *Epiceratodus*, established in 1891 for the recent Lung-fishes. Baldwin Spencer emphatically remarks (1925, p. 249) that Castlenau's "description of its teeth alone proves conclusively that it [Neoceratodus] is quite distinct from the Ceratodus of the Burnett and Mary Rivers."

*"Ceratodus miolepis."*—In 1871 Gunther considered that remarkable differences existed between the Mary River and Burnett River Lung-fishes, and he named the former *Ceratodus miolepis*. He then considered that *C. forsteri* was distinguished by the presence of only eighteen series of scales around the body, whereas twenty-one were found in *miolepis* (p. 516). In his "Challenger" report in 1880, however, Gunther found considerable variation with a far larger series of specimens (p. 32). A. B. Meyer in 1875 considered that the two species should be united, owing to the variation in Gunther's supposed diagnostic character.

Mr. Tom Marshall and I have examined numerous specimens of Ceratodus from the Burnett River, and much variation was found. There may be six series of scales above the lateral lines, and a total of twenty may be counted around the middle part of the body. It seems obvious that Gunther's species cannot stand on this character. Intensive study, however, may show that the Ceratodus from the Burnett watershed may be distinct in certain characters from those of the Mary River and tributaries. Possibly the discrepancies noted in accounts of the habits of these Lung-fishes may be due to physiological differences in specimens from the two distinct habitats. With the exception of the juvenile specimens, which are the progeny of those transported by D. O'Connor from the Mary River in 1895, practically all of our material is from the Burnett River (some of the specimens in the "old collection" are without data), and no adequate comparison can be made at present.

In their list of Queensland Fishes, McCulloch and Whitley (1925, p. 131) recognise but one species, and they note that Macleay's extension of the range of the Lung-fish to the Dawson River was incorrect.

*Common Name.*—Krefft, Semon, Baldwin Spencer, and Thomas Illidge refer to the Lung-fish as the "Burnett Salmon" of settlers. Although Krefft heard that the "Salmon" was "excellent eating," it seems that this name was given on account of the colour and not the palatability of its flesh, for Ceratodus are by no means appreciated by connoisseurs. The alternative name Barramundi ("Baramoonda" or "Baramoondi," Krefft) is more correctly applied to *Scleropages leichhardti* of the Fitzroy and Dawson, although this name is now commonly used by fishermen for the "Palmer," *Lates calcarifer*. Semon states (1899, p. 18) that the natives on the Burnett called Ceratodus "Djellah," whilst O'Connor gives the aboriginal name "Teebine" (1898, p. 493) for the Mary. Theebine—the modern rendering—is the name of a township on the Mary River, and in October, 1922, the name "Ceratodus" was given to a railway station

and settlement on the Burnett. The authorities have thus given prominence to both the native and the original scientific names of the Lung-fish. As a matter of fact the term "Ceratodus" is now widely used in Queensland as the common name of the Lung-fish, and so the old generic name, now replaced by *Epiceratodus,* is still in vogue.

*Fossil Ceratodus.*—Apparently the Dipnoi attained their greatest development in Devonian times. The genus *Ceratodus* first appeared in the Permian, according to E. D. Cope. Examples have been found in Europe, India, Africa, and America. The restricted genus *Epiceratodus* is recorded from the Upper Cretaceous by E. I. White (1926, p. 677). The genus *Gosfordia,* which may represent an allied form from the Lower Hawkesbury Beds (Triassic), Gosford, N.S.W., was described by A. Smith Woodward in 1890. The following references to fossils found in Australia may be useful:—

Gerard Krefft gave the name *Ceratodus palmeri* to a dental plate from alluvial deposits on the Darling Downs, which he considered larger than that of *C. forsteri* (1874, p. 293).

In 1884 De Vis wrote a short paper on several dental plates of Ceratodus which had been found on the Darling Downs. These included the type of Krefft's *Ceratodus palmeri* (p. 42), which had been submitted to Mr. Krefft. De Vis considered that this material was not specifically distinct from the existing Queensland species. Subsequently a dental plate of Ceratodus was obtained "at a depth of about 70 ft. from a well sunk in the Eight-mile Plains near Brisbane" (Jack and Etheridge, 1892, p. 647).

From the Lower Jurassic cliffs of Cape Patterson, Victoria, A. Smith Woodward described *Ceratodus avus* from a lower tooth with four denticles (1906, pp. 1-3). F. Chapman (1912, p. 234) subsequently associated a scale from Jurassic sandstone at Kirrak, S. Gippsland, with this species.

In 1921 W. S. Dun exhibited before the Royal Society of N.S.W., "Teeth of a Ceratodus from late Tertiary deposits at Wentworth" (1922, p. liv). Baldwin Spencer notes teeth from the dry bed of a lake near Wilcannia (1927, p. 248).

Frederick Chapman described *Ceratodus wollastoni* from the Upper Cretaceous of Walgett, N.S.W., from a lower tooth with four denticles. He instituted the sub-genus *Metaceratodus* for this material (1914, p. 25).

In 1925 E. I. White described two new fossil species of *Epiceratodus* (*eyrensis* and *gregoryi*) from the Lake Eyre district of South Australia. These were first noted by Professor J. W. Gregory (1906, p. 81), who also added a note on the geology of Lake Eyre to Mr. White's descriptions (1925, pp. 144-145).

*Epiceratodus pattinsonæ* from the Opal Beds, White Cliffs, N.S.W., Upper Cretaceous, was described by E. I. White in 1926, and this is stated to be the earliest recorded specimen of the genus, as restricted (1926, p. 677).

Stromer and Peyer (1917, p. 76) have noted several characters by which the teeth of *Epiceratodus* may be distinguished from those of *Ceratodus*. The later forms have an increased number of radiating ridges, six being present in *Epiceratodus forsteri*. Although the edges of these ridges, or combs, are not crenulated as in many fossil Dipnoi, Semon has shown that in the embryo there are distinct small conical teeth which become fused in development (Figure 210b, Goodrich, 1909, p. 242).

One splenial dental plate in our collection from an adult *Epiceratodus* is exceptional in having but five ridges.

Two of our fossil dental plates from the Darling Downs are far larger than any obtained from present-day fish. The maximum length across the ridges in the fossil plates attains 57 mm., whereas in a Lung-fish 44 inches in length from the Burnett River the maximum for the dental plate is only 37 mm. Probably *Epiceratodus palmeri* will prove to be a good species, and it evidently attained a large size. Both the large dental plates mentioned are from the lower jaw. Miall's study of the dental plates of *Ceratodus polymorphus* illustrates the variability of some of the fossil species (1878).

D. M. S. Watson and E. L. Gill consider that the genus *Sagenodus* of the Lower and Upper Carboniferous and Lower Permian is essentially ancestral to *Ceratodus* (1923, p. 215).

*Anatomical Work.*—In Huxley's words the Dipnoi "are nearly transitional forms between the Pisces and the Amphibia," and it is not surprising that, as one of the three living representatives of the Dipnoi, *Epiceratodus forsteri* has been the subject for extensive research by numerous specialists. No adequate tabulation can appropriately be given here of the voluminous researches, but some references in addition to those already given are noted, mainly for the use of local students.

Gunther's monograph in the Philosophical Transactions of the Royal Society appeared in 1871, and Huxley's paper (P.Z.S.) in 1876. Some of Semon's work has already been mentioned.

In consonance with the development of an occasionally functioning lung the heart and blood-vessels of Ceratodus have been modified from the ordinary fish type. Baldwin Spencer's finely illustrated paper on "The Blood Vessels" appeared in the Macleay Memorial Volume (1893). A figure of the heart is given by E. S. Goodrich (1909, p. 250).

The leaf-like fins of Ceratodus with their skeletal supports form an archipterygium, and special work on these structures has been done by Gunther, Huxley, Semon, Gegenbaur, Balfour, and Haswell.

Writing of the brain, E. S. Goodrich (1909, p. 245) says that "few organs in the Dipnoi so clearly show the isolation of this sub-class from other fish." Recently additional work on the brain of Ceratodus has been done by Nils Holmgren and C. F. van der Horst (1925).

Many references to special research on the Dipnoi are given in E. S. Goodrich's valuable text-book on Vertebrata Craniata (1909), which itself contains many figures illustrating the anatomy of *Epiceratodus*.